US008561383B2

(12) United States Patent
Suciu et al.

(10) **Patent No.: US 8,561,383 B2**
(45) **Date of Patent: Oct. 22, 2013**

(54) **TURBINE ENGINE WITH DIFFERENTIAL GEAR DRIVEN FAN AND COMPRESSOR**

(75) Inventors: **Gabriel L. Suciu**, Glastonbury, CT (US); **Gino J. Pagluica**, Wells, ME (US); **Loc Quang Duong**, South Windsor, CT (US); **Lawrence E. Portlock**, Bethany, CT (US)

(73) Assignee: **United Technologies Corporation**, Hartford, CT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1645 days.

(21) Appl. No.: **11/719,228**

(22) PCT Filed: **Dec. 1, 2004**

(86) PCT No.: **PCT/US2004/039972**

§ 371 (c)(1), (2), (4) Date: **May 14, 2007**

(87) PCT Pub. No.: **WO2006/059970**

PCT Pub. Date: **Jun. 8, 2006**

(65) **Prior Publication Data**

US 2009/0074565 A1 Mar. 19, 2009

(51) **Int. Cl.**
F02C 1/06 (2006.01)
F02K 3/02 (2006.01)
F02C 1/00 (2006.01)

(52) **U.S. Cl.**
USPC **60/39.163**; 60/772; 60/226.1

(58) **Field of Classification Search**
USPC 60/268, 39.162, 226.1, 39.163; 415/61, 415/68–69; 416/128–129
See application file for complete search history.

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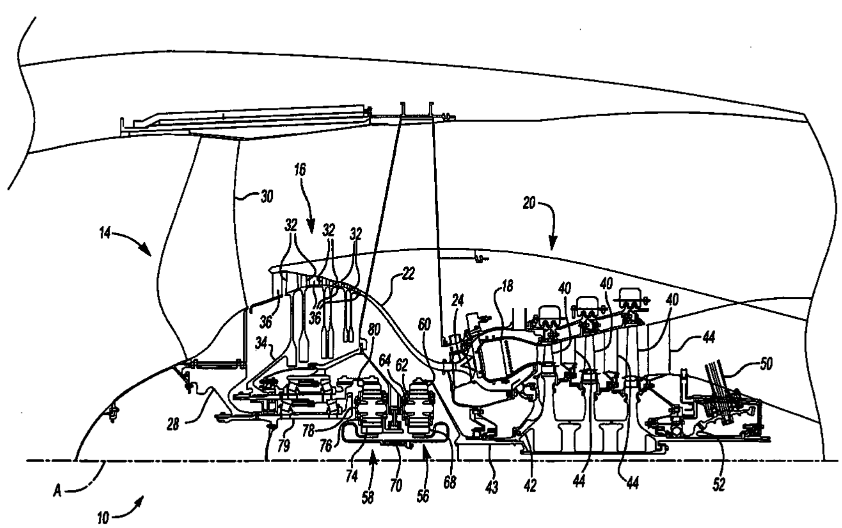
Primary Examiner — Gerald L Sung
(74) *Attorney, Agent, or Firm* — Carlson, Gaskey & Olds, P.C.

(57) **ABSTRACT**

A gas turbine engine (**10**) provides a differential gear system (**58**) coupling the turbine (**20**) to the bypass fan (**14**) and the compressor (**16**). In this manner, the power/speed split between the bypass fan and the compressor can be optimized under all conditions. In the example shown, the turbine drives a sun gear (**74**), which drives a planet carrier (**78**) and a ring gear (**80**) in a differential manner. One of the planet carrier and the ring gear is coupled to the bypass fan, while the other is coupled to the compressor.

13 Claims, 3 Drawing Sheets



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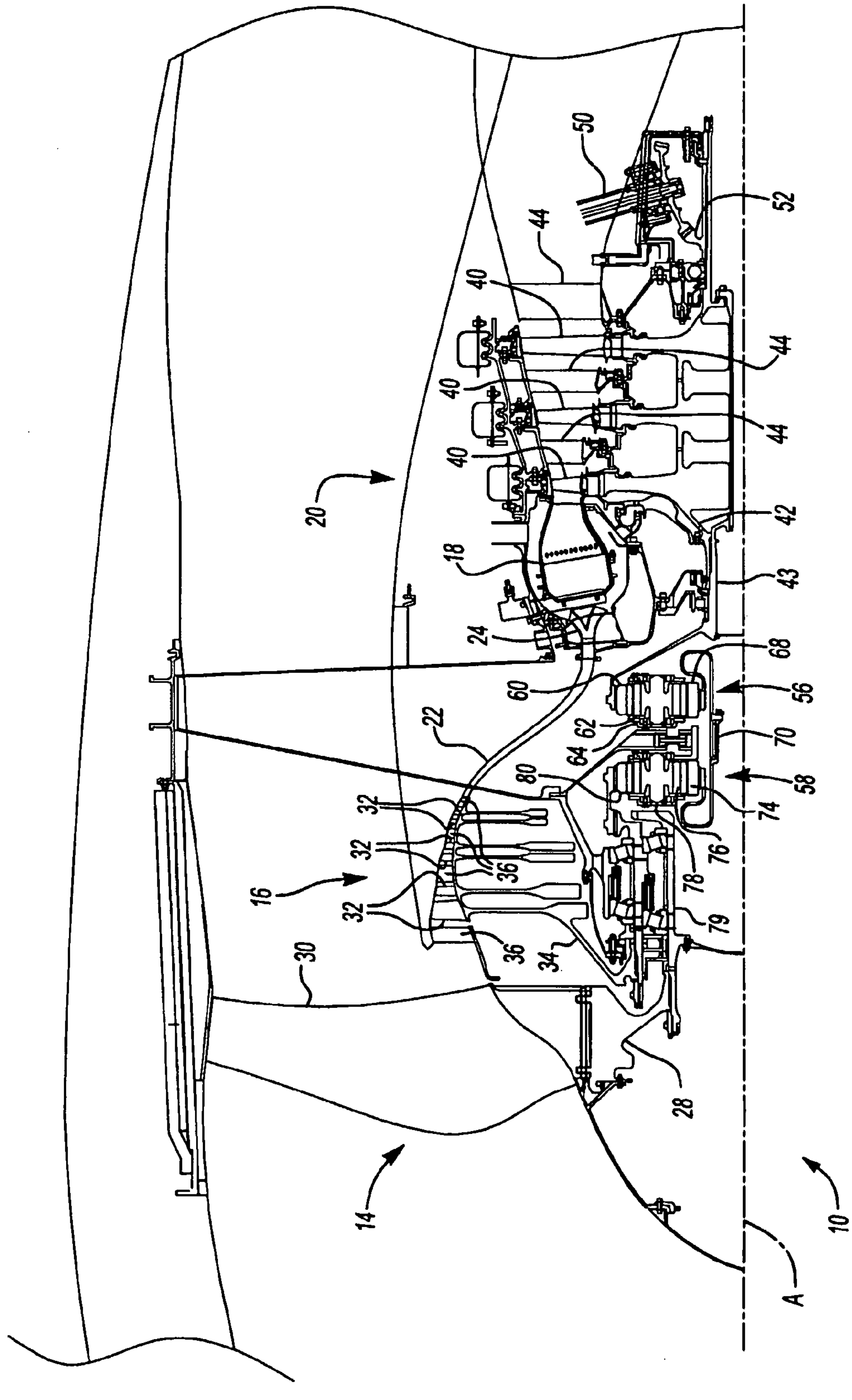

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Fig-1

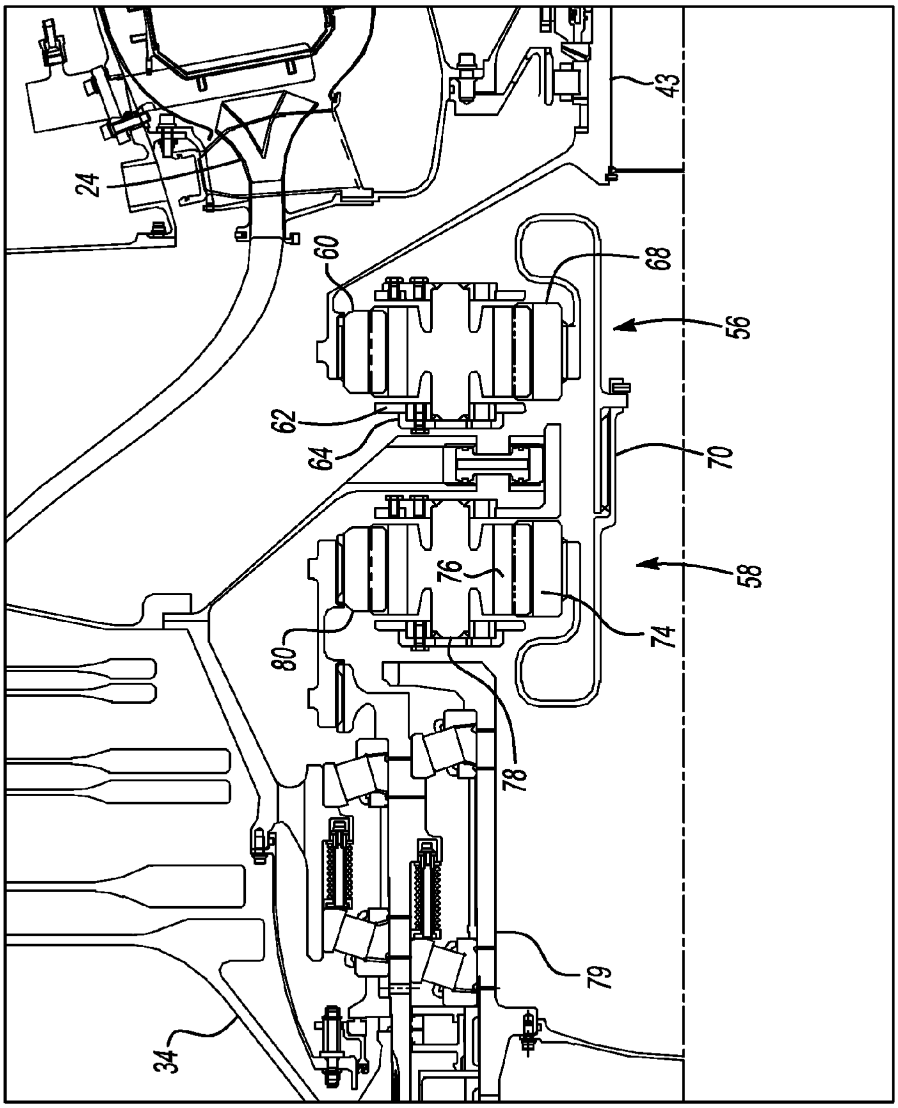

Fig-1A

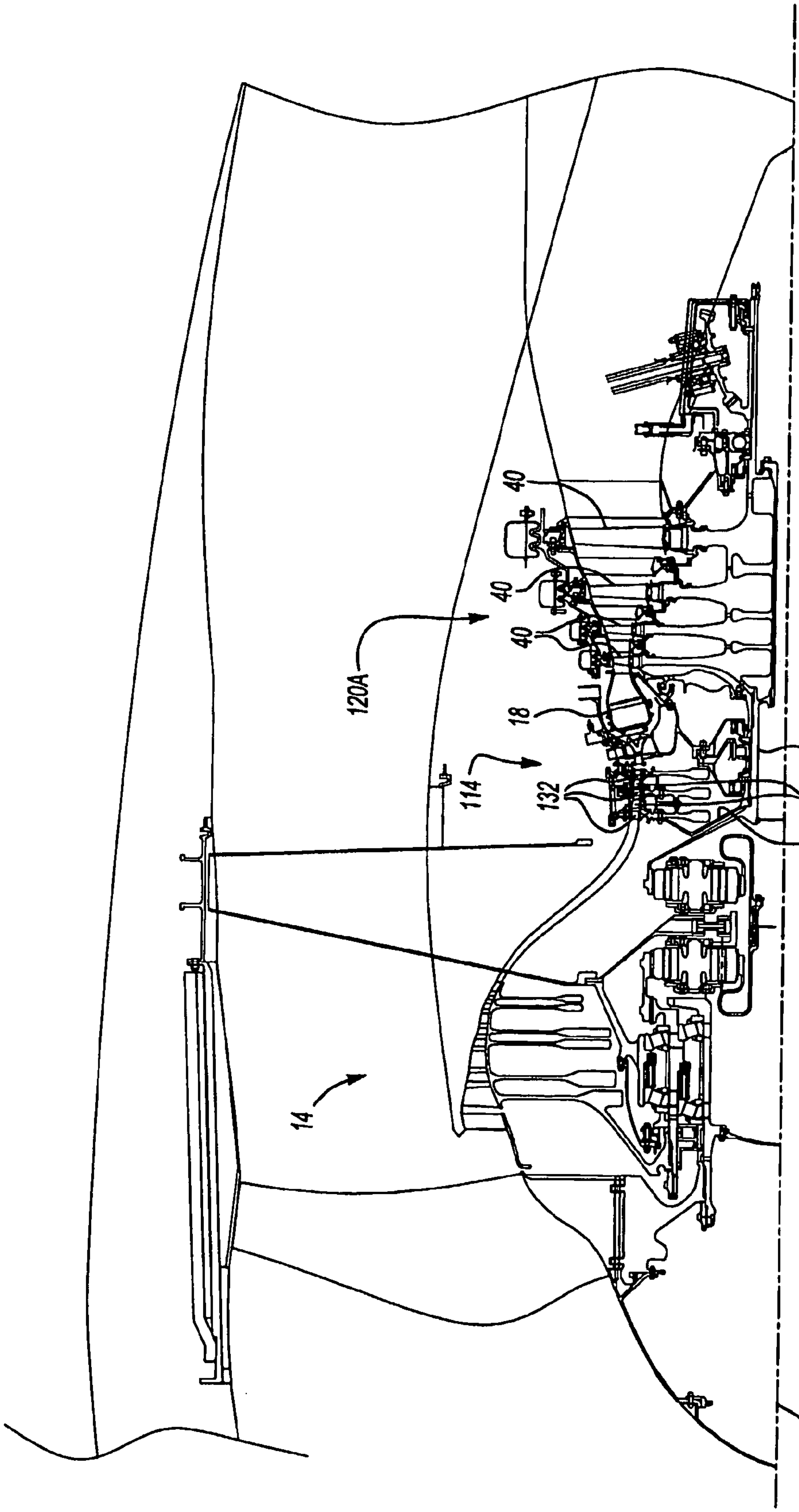

Fig-2

TURBINE ENGINE WITH DIFFERENTIAL GEAR DRIVEN FAN AND COMPRESSOR

This invention was conceived in performance of NASA contract NAS3-98005. The government may have rights in this invention.

BACKGROUND OF THE INVENTION

This invention relates to turbine engines and more particularly to a turbine engine using a differential gear to drive the fan and compressor.

A gas turbine engine, such as a turbo fan engine for an aircraft, includes a fan section, a compression section, a combustion section and a turbine section. An axis of the engine is centrally disposed within the engine and extends longitudinally through the sections. The core air flow path extends axially through the sections of the engine. A bypass air flow path extends parallel to and radially outward of the core air flow path.

The fan section includes a plurality of radially extending fan blades. The fan blades extend through the bypass flow path and interact with the air and transfer energy between the blades and air. A fan case circumscribes the fan in close proximity to the tips of the fan blades.

During operation, the fan draws the air into the engine. The fan raises the pressure of the air drawn along the bypass air flow path, thus producing useful thrust. The air drawn along the core air flow path into the compressor section is compressed. The compressed air is channeled to the combustion section where fuel is added to the compressed air and the air/fuel mixture is burned. The products of combustion are discharged to the turbine section. The turbine section extracts work from these products to power the fan and compressed air. Any energy from the products of combustion not needed to drive the fan and compressor contributes to useful thrust.

In the known turbine engines, the turbine section drives the fan and the compressor at fixed relative rates. However this may not be the ideal power/speed split during all conditions.

SUMMARY OF THE INVENTION

A turbine engine according to the present invention provides a differential gear system coupling the turbine to the bypass fan and the compressor. In this manner, the power/speed split between the bypass fan and the compressor can be optimized under all conditions.

Although not limited to such a configuration, the embodiment shown for purposes of illustration includes an epicyclic differential gear, in particular, a planetary differential gear system. In this example, the turbine drives a sun gear, which drives a planet carrier and a ring gear in a differential manner. One of the planet carrier and the ring gear is coupled to the bypass fan, while the other is coupled to the compressor.

As an additional, optional feature, an amplifying gear system provides a speed increase from the turbine to the differential gear. In the example shown., the amplifying gear system is also an epicycle gear system, in particular, a star gear system. The turbine is coupled to a ring gear, which drives star gears mounted on a carrier mounted to static structure in the turbine engine. The star gears also drive a sun gear, which is coupled to the sun gear of the differential gear system.

In another optional feature, a tower shaft engages a high spool of the turbine aft of the turbine. The tower shaft provides rotational input to the turbine in order to start the turbine engine.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention can be understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. **1** is a partial sectional view of a turbine engine according to a first embodiment of the present invention.

FIG. **2** is a partial sectional view of a turbine engine according to a second embodiment of the present invention.

FIG. **1**A is an enlarged view of the gear systems of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A gas turbine engine **10** circumferentially disposed about an engine centerline A is shown in FIG. **1**. The engine **10** generally includes a fan **14**, a low pressure compressor **16**, a combustor **18** and a turbine **20**. Generally, air compressed in the low pressure compressor **16** is mixed with fuel which is burned in the combustor **18** and expanded in turbine **20**. The air flow path through the low pressure compressor **16**, through the combustor **18** and the turbine **20** may be referred to as the core air flow path **22**.

The fan **14** includes a fan hub **28** and a plurality of fan blades **30**. The plurality of fan blades **30** extends radially outwardly from the fan hub **28** across the bypass air flow path and the core air flow path.

The low pressure compressor **16** includes a plurality of blades **32** extending radially from a compressor rotor **34**. A plurality of static vanes **36** extend between some adjacent pairs of rows of blades **32**. The core air flow path **22** turns radially inwardly between the low pressure compressor **16** and a diffuser **24** leading to the combustor **18**. The low pressure compressor **16** compresses the core air flow, which is then mixed with fuel and ignited in the combustor **18**. The ignited fuel/core air flow mixture expands to create a high energy gas stream from the combustor **18**.

The turbine **20** is downstream of the combustor **18** and includes a plurality of turbine blades **40** extending radially outwardly from a rotatable turbine rotor **42**, which is coupled to a high spool **43**. A plurality of static turbine vanes **44** alternate with the turbine blades **40**.

At least one tower shaft **50** engages a bull gear **52** aft of the turbine **20**. The tower shaft **50** rotatably drives the high spool **43** and the turbine **20** to start the turbine engine **10**.

In the present invention, the turbine rotor **42** is coupled via a pair of gear systems **56**, **58** to rotatably drive the bypass fan **14** and the compressor rotor **34**. Generally, the first gear system **56** amplifies the rotational speed of the input from the turbine **20**. The second gear system **58** is a differential gear system, providing optimum power/speed splits between the bypass fan **14** and the compressor rotor **34** of the low pressure compressor **16**.

Referring to FIG. **1**A, the first gear system **56** shown is a star gear system in which the high spool **43** is directly coupled to a ring gear **60** which rotates with the turbine **20**. The ring gear **60** engages a plurality of star gears **62** on a carrier **64** that is fixed to the static structure of the turbine engine **10**. The star gears **62** engage a sun gear **68**, which is the output of the first gear system **56**. The first gear system **56** provides a rotational speed increase from the turbine to the sun gear **68** and also reverses the direction of rotation from the ring gear to the sun gear.

The sun gear **68** of the first gear system **56** is coupled, such as via a flex coupling **70**, to a sun gear **74** on the second gear system **58**. The sun gear **74** engages planet gears **76** on a

planet carrier **78** that is coupled to the fan hub **28**. via a fan shaft **79**, such that the fan hub **28** rotates with the planet carrier **78**. The planet gears **76** also engage a ring gear **80** that is coupled to the compressor rotor **34**, such that the compressor rotor **34** rotates with the ring gear **80**. Because the second gear system **58** is an epicyclic gear system, and more particularly a planetary gear system, with the ring gear **80**, planet carrier **78** and sun gear **74** all un-fixed relative to the static structure of the turbine engine **10**, the second gear system **58** acts like a differential gear system providing an optimum power/speed split between the compressor rotor **34** of the low pressure compressor **16** and the bypass fan **14**. As one of the compressor rotor **34** and the bypass fan **14** encounters more resistance, more speed is transferred to the other of the compressor rotor **34** and the bypass fan **14**.

In operation, the low pressure compressor **16** compresses the core air flow, which is then mixed with fuel and ignited in the combustor **18**. The ignited fuel/core air flow mixture expands to create a high energy gas stream from the combustor **18**, which rotatably drives the turbine blades **40**. Rotation of the turbine rotor **42** drives high spool **43**. The high spool **43** rotatably drives the ring gear **60** in the first gear system **56**. The ring gear **60** rotatably drives the star gears **62** to drive the sun gear **68** at a higher rate, which is coupled to the sun gear **74** of the second gear system **58**. Rotation of the sun gear **74** drives the bypass fan **14** via the planet carrier **78** and the low pressure compressor **16** via the ring gear **80**. The second gear system **58** is a differential gear system, which varies the relative rotation rates of the bypass fan **14** and the low pressure compress **16** over time, based upon current conditions.

FIG. **2** illustrates a turbine engine **110** according to an alternate embodiment of the present invention. The turbine engine **110** includes everything shown and described above with respect to the turbine engine **10** of FIG. **1**. Therefore, that description will not be repeated. and only the differences will be described. The turbine engine **110** of FIG. **2** additionally includes a high pressure compressor **114** between the low pressure compressor **16** and the combustor **18**. The high pressure compressor **114** is also radially inward of the low pressure compressor **16**. The high pressure compressor **114** includes a plurality (three shown) of stages of compressor blades **132** extending radially from a compressor rotor **134** and alternating compressor vanes **136**. The compressor rotor **134** is directly coupled to the high spool **43** such that the compressor rotor **134** of the high pressure compressor **114** rotates at the same rate as the turbine **20**A.

The high pressure compressor **114** provides additional compression of the core air flow into the combustor **18**. It is expected that this design would operate at an operating pressure ratio of approximately twice that of the first embodiment. Consequently, and to assist in driving the high pressure compressor **114**, the turbine **20**A includes an additional stage. of turbine blades **40** compared to the first embodiment.

In accordance with the provisions of the patent statutes and jurisprudence, exemplary configurations described above are considered to represent a preferred embodiment of the invention. However, it should be noted that the invention can be practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.

The invention claimed is:

1. A turbine engine comprising:

a turbine;

a fan driven at a first rate by the turbine;

a compressor downstream of the fan, the compressor driven at a second rate by the turbine, the first rate and the second rate varying relative to one another over time, the compressor including a compressor rotor from which a plurality of compressor blades extend radially; and

a planetary gear system providing a driving engagement between the turbine and the fan and between the turbine and the compressor, the planetary gear system including a sun gear, a planet carrier, at least one planet gear carried by the planet carrier and driven by the sun gear, and a ring gear driven by the planet gear; and

wherein the fan is coupled to the planet carrier, the compressor rotor coupled to the ring gear of the planetary gear system, the turbine coupled to the sun gear.

2. A turbine engine comprising:

a turbine;

a fan driven at a first rate by the turbine;

a compressor driven at a second rate by the turbine, the first rate and the second rate varying relative to one another over time, the compressor including a compressor rotor from which a plurality of compressor blades extend radially;

a planetary gear system providing a driving engagement between the turbine and the fan and between the turbine and the compressor, the planetary gear system including a sun gear, a planet carrier, at least one planet gear carried by the planet carrier and driven by the sun gear, and a ring gear driven by the planet gear; and

an amplifying gear system coupled between the turbine and the sun gear, the amplifying gear system increasing a rate of rotation of the sun gear relative to the turbine, wherein the fan is coupled to the planet carrier, the compressor rotor coupled to the ring gear of the planetary gear system, the turbine coupled to the sun gear.

3. The turbine engine of claim **2** wherein the planetary gear system is a differential planetary gear system and wherein the amplifying gear system is an amplifying star gear system.

4. The turbine engine of claim **3** wherein the turbine is coupled to a ring gear of the amplifying star gear system and wherein a sun gear of the amplifying star gear system is coupled to the sun gear of the differential planetary gear system.

5. The turbine engine of claim **2** wherein the compressor rotor is rotatable about an axis and wherein the fan is axially forward of the compressor.

6. The turbine engine of claim **5** wherein the fan is configured to move air downstream, which is axially rearward in the turbine engine.

7. The turbine engine of claim **6** wherein the compressor is downstream of the fan.

8. The turbine engine of claim **2** wherein the compressor is downstream of the fan.

9. A method for operating a turbine engine including the steps of:

driving a sun gear of a differential gear system with a turbine via an amplifying gear system at a rate of rotation higher than a rate of rotation of the turbine;

driving a bypass fan with a planet carrier of the differential gear system at a first rate; and

driving a compressor with a ring gear of the differential gear system at a second rate, a ratio of the first rate relative to the second rate varying over time.

10. The method of claim **9** wherein the compressor is downstream of the fan.

11. The method of claim **9** wherein the compressor is rotatable about an axis and wherein the fan is axially forward of the compressor.

12. The method of claim **11** wherein the fan is configured to move air downstream, which is axially rearward in the turbine engine.

13. The method of claim **12** wherein the compressor is downstream of the fan.

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